Use with: DELU-V-02-001

DELU-E-02-002 C2

EXTREME 2002

CURRICULUM GUIDE AND FRAMEWORK

See also: DELU-E-02-001

Sea Grant UNIVERSITY OF DELAWARE

THE GRADUATE COLLEGE OF MARINE STUDIES

SEA GRANT
COLLEGE PROGRAM
MARINE PUBLIC EDUCATION OFFICE

University of Delaware
Newark, Delaware 19716-3530
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September 18, 2002

Dear Teacher:

Welcome aboard *EXTREME 2002: Mission to the Abyss!* Thank you for registering for this unique educational program sponsored by the National Science Foundation and the University of Delaware, with additional support from NOAA Sea Grant, WHYY-TV, and the MBNA Foundation. We are thrilled to have you and your classroom join us for an exciting 24-day expedition to hydrothermal vents in the Pacific Ocean, starting October 20 to November 12!

Your classroom is one of more than 500 middle- and high-school classrooms (representing about 40,000 students) on our Extreme team. Our registrants hail from the United States, Canada, Australia, New Zealand, and South Africa. When the expedition begins, our Web site ***(www.ocean.udel.edu/extreme2002)*** will be the chief communications link between the scientists at sea and your classroom on shore.

Your resource package should include the following items:

(DELU-E-02-001)

(1) EXTREME 2002 RESOURCE GUIDE — This colorful guide provides an overview of hydrothermal vents, the creatures that inhabit vent sites, and the technology that makes deep-sea research possible.

(2) EXTREME 2002 VIDEO — This 45-minute video, produced by WHYY-TV (PBS, Wilmington/Philadelphia), includes segments on "The Deep Ocean," "Plate Tectonics," "Deep-Sea Dwellers," and "The Pompeii Worm." ⇐

DELU-V-02-001

DELU-E-02-002

(3) EXTREME 2002 CURRICULUM GUIDE & FRAMEWORK — This 31-page teacher's guide describes how the most important goals of Extreme 2002 can be met through the dedication of approximately five classroom periods. Includes descriptions of each Extreme 2002 resource, a possible classroom schedule, and supplementary activities.

(4) EVALUATION — Includes student pre- and post-tests and a teacher evaluation of the project. This is a critical requirement of your participation in Extreme 2002. We need your input in order to improve our program and garner continued support for future expeditions.

(5) SAMPLE PRESS RELEASE — One copy for personalization by your school. Let your local media know about your classroom's participation in this innovative program.

****ADDITIONAL VIDEO FOR PHONE CALL PARTICIPANTS** — The 50 schools for the "Call to the Deep" have been notified. If your classroom has been selected, your package should contain *Diving into the Deep: A Silent Movie.* It is meant to serve as a visual backdrop to the call. More details will be coming soon by e-mail.

If you have questions about your resource package, contact us at *MarineCom@udel.edu* or (302) 831-8083. As our preparations speed along, please check your e-mail frequently for updates. We look forward to your participation, and we thank you for giving your students the opportunity to dive into the deep sea with us!

Sincerely yours,

Craig Cary

Dr. Craig Cary
Chief Scientist, Extreme 2002

Tracey Bryant

Ms. Tracey Bryant
Director, Marine Public Education Office

Here is a press release that you may customize for your school and then send to the media in your area to let them know about your participation in this special project.

Local Students Take Part in Deep-Sea Adventure

Students at [YOUR SCHOOL'S NAME] will take a voyage deep into the Pacific Ocean with scientists from the University of Delaware beginning Oct. 20 as part of *Extreme 2002: Mission to the Abyss*, a research expedition that will be broadcast internationally via the Internet.

A scientific team led by UD marine biologist Craig Cary will set sail aboard the 274-foot research vessel *Atlantis* from San Diego, California, for a 24-day mission to explore the ocean's depths. Once at the Pacific Ocean dive site, the scientists will climb aboard the submersible *Alvin* and plummet to one of the most demanding environments on Earth — super-hot hydrothermal vents over a mile deep on the ocean floor. Both the sub and the research vessel are owned by the U.S. Navy and operated by Woods Hole Oceanographic Institution.

Under Dr. Cary's direction, researchers will study the vents and the organisms that inhabit them, including the Pompeii worm, which is regarded as the Earth's most heat-tolerant animal, able to withstand temperatures up to 176° Fahrenheit.

About 40,000 students at 500 schools are participating in *Extreme 2002*. They represent nearly every U.S. state, the District of Columbia, and Puerto Rico, as well as Australia, Canada, New Zealand, and South Africa. Students and the public can log on to the expedition Web site at www.ocean.udel.edu/extreme2002 and see the scientists' latest discoveries via video clips, photos, interviews, and journals that will be relayed daily back to shore. Students also will have an opportunity to interact electronically with members of the research team, and selected schools will participate in a live conference call with the scientists working live aboard the submersible *Alvin* on the seafloor.

Extreme 2002: Mission to the Abyss is sponsored by the University of Delaware Graduate College of Marine Studies with financial support from the National Science Foundation, NOAA Sea Grant, WHYY TV, and the MBNA Foundation.

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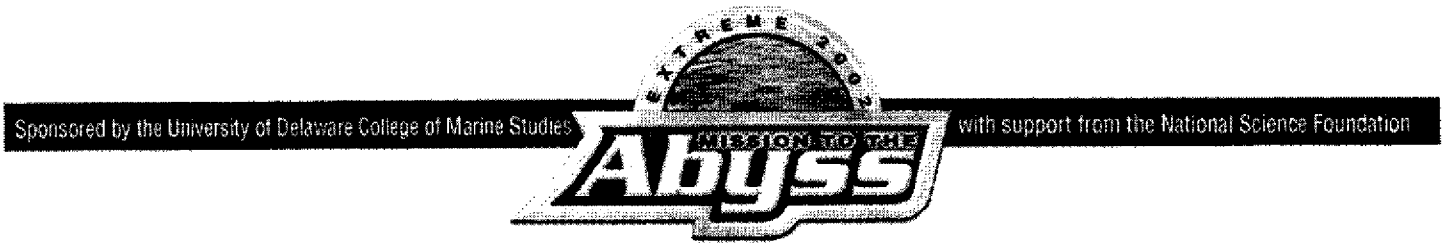

Curriculum Guide and Framework

by Amy Hacker, Math/Science Teacher, Cape Henlopen High School, Lewes, Delaware

Thank you for choosing to participate in Extreme 2002. You have been provided with several types of materials designed to enhance teaching and learning experiences for you and your students. The most important goals of Extreme 2002 can be met through the dedication of approximately five classroom periods during which your students will be exposed to a variety of resources intended to help them learn about cutting-edge research in the deep sea, particularly as it relates to hydrothermal vent ecosystems. Brief descriptions of each resource available to you will be followed by a possible classroom schedule. Many of you may wish to extend your students' learning opportunities through additional dedicated classroom time. If so, several supplementary activities have been included in this guide. Any or all of them may be used to supplement the basic curricular outline. We hope that these resources will be useful to you, and we are excited to be involved with you and your students' voyages of discovery.

Guide to Available Resources

Extreme 2002: Resource Guide

You have been provided with an exceptionally informative magazine-style resource guide for each of your students. This resource guide begins with an introduction and is further organized into sections that correspond with those in the video presentation. The back page has a "Delve Deeper" section that is designed to encourage students to pursue understanding beyond what is available in their resource guides. The resource guide contains additional in-depth facts and evaluation as well as information specific to the Extreme 2002 dives. The resource guide is organized into sections on "Geology," "Biology," and "Exploring the Deep."

The "Geology" section is designed to help students get their bearings with respect to both geology and geography. It pinpoints the location of the Extreme 2002 dive and includes information on tectonic plates and hydrothermal vent formation and geology.

The "Biology" section includes a general description of the vent environment, the unique community of organisms that resides there, and the unusual adaptations that enable vent dwellers to survive the demands of their environment. The highlight of this section is the Pompeii worm because it is the focus of the Extreme 2002 research mission. This section also includes details on temperature and pressure adaptations as well as the significance of chemosynthesis to the maintenance of the unique hydrothermal vent ecosystem. There is

additional information about the bacteria found at these locations, and a discussion of the rationale and benefits of current biological research in the deep sea. The "Creatures of the Deep" sidebar contains photographs and information about several deep-sea organisms.

The "Exploring the Deep" section highlights the submersible *Alvin* and its mother ship, *Atlantis*. It investigates the history of deep-sea exploration to draw connections among science, technology, and society. It emphasizes the inherent difficulties of deep-sea research and the pioneering scientists and divers who led and continue to lead developments in deep-sea investigation.

Extreme 2002: Mission to the Abyss Video Presentation

You have been provided with an exceptionally informative video that contains excellent footage of life in the deep sea as well as interviews with scientists who are actively involved with hydrothermal vent research. The video was produced by WHYY TV in collaboration with the University of Delaware College of Marine Studies. The video begins with a brief introduction where students meet Dr. Craig Cary, chief scientist. The rest of the video is organized into four sections. Each of the first three sections is approximately 10–13 minutes long. These sections each have a specific emphasis and were designed to serve as an introduction to a particular topic. It is recommended that students watch one section per day. On the third day, the students may also view the fourth video section on the Pompeii Worm, an important focus of the Extreme 2002 research efforts. Reproducible study guides for each video section are included in this curriculum guide.

Part 1 of the video is entitled *Deep Ocean*. This section serves as a general introduction to the biology and geology of the deep sea. It also describes the difficulties and excitement inherent in conducting scientific research in such an extreme and relatively inaccessible environment.

Part 2 of the video is entitled *Plate Tectonics*. This section provides an introduction to the theory of plate tectonics with specific emphasis on those plate boundary interactions that are of particular importance in the deep-sea. It discusses mid-oceanic spreading zones where movement of crustal plates away from one another gives rise to hydrothermal vents and their associated assemblages of organisms.

Part 3 of the video is entitled *Deep-Sea Dwellers*. This section discusses the unique biological characteristics of hydrothermal vent organisms and communities. The important concepts of chemosynthesis (where energy is extracted from hydrogen sulfide rather than sunlight) and symbiosis are introduced.

Part 4 of the video in entitled *The Pompeii Worm*. This 5-minute final section focuses on the biology of the unique Pompeii Worm, which is one essential focus of the Extreme 2002 expedition. This section also introduces students to Hepsi Zsoldos, an Earth science teacher at Talley Middle School in Wilmington, Delaware, and Jen Costanza, a graduate student at the University of Delaware College of Marine Studies, who are serving as ship-board education coordinators for the Extreme 2002 mission.

Extreme 2002: Web Site

This fascinating Web site is an elaborated version of the award-winning Extreme 2000 and Extreme 2001 Web sites. It can be accessed on-line at www.ocean.udel.edu/extreme2002. Much of the content of the resource guide is mirrored in an interactive fashion on this site within the major headings ranging from "Mission and Crew" to "High-Tech Tools." A couple of the more novel components in these sections are a close-up of the "star" Pompeii worm including an audio narrative by Dr. Craig Cary, chief scientist. Another feature is a 3-D model of the submersible *Alvin* (a Quicktime Virtual Reality) in which students are able to "pilot" the sub and view, up close, various geological features and organisms.

Another novel addition to the site is "Marina, the Dive Assistant" located in the lower righthand corner. Once activated, this animated, 3-D character will point out special features and useful information during the expedition.

In a further effort to bring the excitement and struggles of real research into the classroom, the Web site also contains a "Daily Discoveries" section that will include daily journal entries posted by the scientists and crew during the expedition, "Neat Stuff" featuring photos and video clips of what the scientists are doing and discovering, interviews with various members of the expedition team, and dive logs.

Several special activities are listed under "Extreme Activities." In "Extreme Experiments," classrooms will be invited to design an experiment — one per classroom — for the scientists to conduct at sea. The scientists will select several of the experiments to perform, and the results will be posted on the Web site. You will receive more details about this activity as the expedition nears. In "Write the Scientists," students periodically will be invited to e-mail questions to science team members. While a limited number of schools have been selected to participate in the "Call to the Deep" — a real-time phone conversation with scientists aboard *Alvin,* all students can vicariously participate in these conversations by listening to the phone calls as they are posted on the Web site. The Internet site is an important educational resource for this project and students should be encouraged to access it as much as time allows.

A special resource for you on the Web site is the "Teacher's Corner." It will provide information about how Extreme 2002 meets the National Science Education Standards, provide access to on-line versions of the program evaluations (which are critical), and offer a password-protected forum area where you can share teaching techniques and project ideas with your fellow Extreme 2002 teachers.

Also be sure to check out the list of participating schools (button near the Teacher's Corner) to find out the extensive community of classrooms in the United States, Australia, Canada, New Zealand, and South Africa that are involved in Extreme 2002. Additionally, if you are interested in seeking other print and Web-based resources relating to the deep sea, you should find the "Resources" button a good starting point for more information.

Suggested 5-Day Schedule

(50-minute class periods)

Day 1

- Introduce the "virtual field trip" concept including the specifics and location of the Extreme 2002 research cruise. Discuss the importance of scientific research and the excitement of being involved with and having access to cutting-edge research in the deep-sea. (5-10 min)
- Distribute the video presentation study guides for *Part 1: Deep Ocean* and watch the introduction and the first 11-13 minute video section.
- Review and discuss the video including student responses to each of the study guide questions. (25 min)
- Distribute the student Resource Guides and introduce students to their organization and content. In order to meet the most important of the Extreme 2002 educational objectives, it is essential that students read and assimilate much of the content of the resource guide. It goes without saying that the more they understand the background and research goals of the program, the more personally invested they will become. Depending on your students, you may wish to assign the reading of specific sections as homework (perhaps using the supplementary vocabulary assignment or the writing of article reviews to structure their reading), or use additional class time to ensure that they read and comprehend the different sections of the resource guide. For today, focus their attention on the "Exploring the Deep" section and develop a strategy for their becoming conversant with its content. (10 min)
- Inform students of the Extreme 2002 interactive Web site and encourage them to access it at home if they are able to do so.
- Supplementary activities *Construct a Sub*, *Write about It,* and *Vocabulary in Context* may be specifically applicable to reinforcing today's content.

Day 2

- Review class discussions from Day 1 and complete the implementation of your strategy for ensuring students have read and understand the "Exploring the Deep" section of their resource guide. (5-10 min)
- Distribute the video presentation study guides for *Part 2: Plate Tectonics* and watch the 11-13 minute video section.
- Review and discuss the video including student responses to each of the study guide questions. (25 min)
- For today, focus students' attention specifically on the "Geology" section of their resource guides and develop a strategy for their becoming conversant with its content. (10 min)
- Supplementary activities *Crustal Plates Laboratory*, *Write about It,* and *Vocabulary in Context* may be specifically applicable to reinforcing today's content.

Day 3

- Review class discussions from Day 2 and complete the implementation of your strategy for ensuring students have read and understand the "Geology" section of their resource guide. (5 min)
- Distribute the video presentation study guides for *Part 3: Deep-Sea Dwellers* and watch the 11-13 minute video section.
- View the final 5-minute video section, *The Pompeii Worm.*
- Review and discuss the video including student responses to each of the study guide questions. (20 min)
- For today, focus students' attention specifically on the "Biology" section of their resource guides and develop a strategy for their becoming conversant with its content. (10 min)
- Supplementary activities *Making a Mural*, *Deep-Sea Organisms*, *Design an Organism*, *Write about It,* and *Vocabulary in Context* may be specifically applicable to reinforcing today's content.

Day 4

- Review class discussions from Day 3 and complete the implementation of your strategy for ensuring students have read and understand the "Biology" section of their resource guide. (5-10 min)
- The interactive Web site certainly deserves at least a day of dedicated classroom time. If you have a computer lab available and/or sufficient numbers of classroom computers so that students can work in small groups, it will certainly be worth their while to explore the Web site at their own pace and according to their own interests. As some schools will need to submit questions to the scientists for use during the culminating seafloor conference call, you may wish to have students develop a list of questions for the researchers that are based upon their explorations up to this point. Guide students individually or in groups toward those Web components they will find of most particular use or interest depending upon your particular curricular needs. (40-45 min.)
- Supplementary activity *Web Quest* may be specifically applicable to reinforcing today's content.

Day 5

- For many schools, the final day of dedicated classroom activities will center on the culminating Extreme 2002 event: a real-time conference phone call with scientists aboard *Alvin* on location at a hydrothermal vent site at 9° N. Fifty schools will be selected to participate in one of four calls, in which students will have the opportunity to ask questions of researchers in the sub.
- Due to the huge interest in this program (over 500 schools and 40,000 students), not all schools will have the opportunity to be in direct voice contact with members of the *Alvin* crew. However, all schools will be able to listen to the conversations as they are posted on the Web and can submit questions to the scientists via the "Write the Scientists" feature. Teachers may also elect to use any of the Supplementary Activities included in this packet to enhance their students' Extreme 2002 experience.

Name_____ Date_____

Study Guide: Extreme 2002: Mission to the Abyss Video

Part 1: Deep Ocean

As you listen to the video presentation, write answers to the following questions. Your teacher may pause the video to further explain or discuss specific topics.

1. How deep is most of the ocean?

2. What percentage of the Earth's surface is covered with water?

3. What is the continental slope?

4. Oceanic researchers often speak of the "Twilight Zone". What do they mean by this term and how deep is the water to which they are referring?

5. What is one way in which fish in the deep sea are specifically adapted for life in that region?

6. What is *Alvin?*

Name_____ Date_____

Study Guide: Extreme 2002: Mission to the Abyss Video

Part 1: Deep Ocean (continued)

7. What are some of the things researchers take with them on a dive to the deep sea?

8. How long does it typically take to get to the bottom of the ocean?

9. What does Dr. Cary consider to be the primary goal of deep-sea exploration?

Question for thought: Which aspect of deep-sea research would be the most personally difficult for you? Which aspect would be the most rewarding?

Name_____ Date_____

Study Guide: Extreme 2002: Mission to the Abyss Video

Part 2: Plate Tectonics

1. What geologic structure was produced when the India Plate crashed into the European Plate?

2. Describe the process that produces oceanic trenches.

3. What geologic process produces the mid-oceanic ridges and rises?

4. How fast do most plates move?

5. What is a hydrothermal vent?

6. Pressure changes the boiling point of water. What is the boiling point of water at the bottom of the ocean? Is the pressure higher or lower than at the surface?

7. What was one of the most biologically significant discoveries at hydrothermal vents?

Question for thought: Based on what you have learned about hydrothermal vents, what do you think might be the cause of terrestrial volcanoes?

Name_____ Date_____

Study Guide: Extreme 2002: Mission to the Abyss Video

Part 3: Deep-Sea Dwellers

1. How large can vent tubeworms grow? Vent clams?

2. What is the function of endosymbiotic bacteria? How do they benefit the host organism?

3. Which chemical species are measured by Dr. Luther's microelectrode?

4. What is the "sipper" and how is it used?

5. Who or what is the major source of funding for hydrothermal vent research?

Name_____ Date_____

Study Guide: Extreme 2002: Mission to the Abyss Video

Part 3: Deep-Sea Dwellers (continued)

6. What physical features of hydrothermal vents make them particularly extreme environments?

7. How might basic research in the deep sea be applied to meet the needs of a growing human population?

8. Describe the visible features of Europa that lead scientists to hypothesize that it may harbor life forms.

Question for thought: What is the ultimate source of energy in hydrothermal vent communities? How does this differ from marine communities in the top 100 meters of the ocean?

Supplementary Activity-Based Lessons

The following activities consist of ideas for further enrichment and/or as ways to extend your experience of Extreme 2002 beyond a week's worth of class time. They are not required, but may prove useful in highlighting particular concepts. Several of the following suggested assignments can be used to bridge disciplines or to integrate your experience of Extreme 2002 throughout other curricular areas.

This section of the curriculum guide begins with a brief description of each supplementary pursuit along with notes for its implementation. The descriptions are followed by reproducible student-copy for some of the activities.

Make a Mural

Depicting a cross-section of the ocean by making a ceiling-to-floor-sized mural on a large sheet of butcher paper or newsprint is a wonderful way for students to construct an internal visual image of oceanic life zones and their inhabitants. This activity requires students to work in cooperative groups, use measuring skills, and synthesize the biological content they have learned. It is particularly well suited to students with kinesthetic and sensorial learning modes.

Put students into groups of three or four, and give them an 8-ft sheet of butcher paper, tempera paints and brushes, a yardstick (or meter stick), and the following instructions. They should use different shades of blue paint (add white to lighten the blue) to accurately depict the various light zones of the ocean under which hydrothermal vents are located: the euphotic zone (where there is enough light for photosynthesis to occur, up to about 100 m), the twilight zone (where there is a slight amount of light, 100 m – 475 m), and the aphotic zone (into which no light penetrates, 475 m – bottom). These depths are necessarily approximate as light penetration depends on a variety of factors and differs among locations.

You may wish to ask your students to calculate the amount of their butcher paper that should represent each of the life zones, assuming an oceanic depth of 2,500 meters. Alternatively, using a scale of 1 in = 25 meters, on an 8-ft sheet of paper, the top 4 inches will be euphotic zone, the next 14 – 15 inches will be twilight zone, and the remainder will be aphotic zone (deep sea). Once the students have correctly established each life zone, ask them to allow the paint to dry and then add the organisms that inhabit each depth. They may wish to paint in the organisms, or they may draw them on separate paper and tape them onto the mural. If you wish to further highlight the importance of scale, instruct your students that the largest hydrothermal vent chimney yet discovered measured 65 m; it was located on the Juan de Fuca Ridge and nicknamed "Godzilla." You may wish to have them add this feature "to scale" on their murals.

A wonderful selection of midwater animals can be found at http://people.whitman.edu/~yancey/midwater.html.

Construct a Sub

You may wish to have students use the *Alvin* statistics in their resource guides to construct a scale model of *Alvin*, operated by the Woods Hole Oceanographic Institution. Their Web Site www.whoi.edu contains drawings, photographs, and simulations of research activities aboard the submersible.

It is also extremely instructive to students to use masking tape to delineate a 6-ft diameter sphere on the floor of the classroom and let them know that this is the space into which the *Alvin* crew of three people must squeeze for the 6 – 10 hour dive duration. You may wish to further enhance their appreciation for the cramped conditions by having students construct cardboard consoles, video cameras, computers, and data recording systems to put into the space representing the submersible. Then, ask three volunteers to occupy the space and complete their class work, for the duration of a class period. This is a fun and humorous activity that will help bring scientific loftiness down to a more manageably human scale.

Vocabulary in Context

You may wish to have students define the technical terms on the reproducible student sheets and determine their relevance to the study of the deep sea. The vocabulary terms are listed by subject area and roughly correspond to the content specific to each of the first three days of the Extreme 2002 curriculum outline. These can serve as appropriate homework assignments.

Deep-Sea Organisms

There are many interesting organisms that inhabit the deep-sea. Help your students to gain experience and proficiency in independent research by asking them to research the taxonomy and basic biology of a member of the deep-sea fauna. You may choose to guide their research by assigning students to particular organisms. The list below is provided for your use. Additionally, included in this packet is a reproducible deep-sea organisms work sheet that may help focus your students' research. Information on deep-sea organisms can be difficult to locate, and some students may not be able to obtain information about all the areas on their worksheet. The Extreme 2002 Web site will prove invaluable in this regard.

Animals

Large tubeworm – *Riftia pachyptila*
Small tubeworm – *Tevnia jerichonana*
Vent mussel – *Bathymodiolus thermophilus*
Vent crab – *Bythograea thermydron*
Vent clam – *Calyptogena magnifica*
Pompeii worm – *Alvinella pompejana*
Polychaete worms – *Paralvinella sp.*
Fang Tooth – *Anoplogaster cornuta*
Net Devil Anglerfish – *Linophryne arborifer*
Dragonfish – *Tactostoma macropus*
Viperfish – *Chauliodus macouni*
Vampire Squid – *Vampyroteuthis*

Design an Organism

Help students to integrate their understanding of adaptation with their growing awareness of the environmental parameters at work in hydrothermal vent ecosystems. Ask them to design a fictional organism that is adapted to life in or around a hydrothermal vent. Their organisms will need to be able to deal with extreme temperature, chemistry, pressure, and darkness. Have them create a poster presentation that includes a picture and description of the organism they have designed, with particular emphasis on specialized adaptations that enable it to thrive and reproduce in such an extreme environment.

Mathematics Applications

Science and mathematics are inextricably linked. Extreme 2002 provides a wonderful opportunity for students to practice their math skills in context and to appreciate the importance of mathematics to solving real-world scientific problems. These student-reproducible situational math problems will aid students in developing their data analysis and problem-solving skills.

The problems have been divided into specific headings relevant to deep-sea research. These are technical support, life support, data analysis, and project support. They can be used in the classroom in any number of ways. Each student might be asked to solve all of the problems, or students might be responsible for specific problems individually or in a group. Problems range in difficulty from those involving algebra (only Technical Support I) to those that can be solved through the use of simple arithmetic. To enable students of varying abilities, you may wish to construct technical support, life support, data analysis, and project support groups that are responsible for each problem type, respectively. For your convenience and use as a follow-up, there are two separate problem sets with fundamentally similar problems involving different specific calculations. These are entitled Mathematical Applications I and Mathematical Applications II.

Crustal Plates Laboratory

An understanding of plate tectonics is an important part of the academic content of Extreme 2002. This is a good pencil-and-paper lab that will help students deepen their understanding of the consequences of crustal plate movements. It explores the relationships among plate boundaries, earthquakes, and volcanoes by asking students to plot the latitude and longitude of recent eruptions and quakes on a world map that has the plate boundaries marked. When sufficient numbers of tectonic events are plotted, plate boundaries are clearly delineated.

Some data concerning recent earthquakes and volcanic activity have been included in this packet along with the reproducible laboratory activity. You may choose to provide students with these data, or find the most current volcanic activity and earthquake data on the Web sites from which the included data originated. These Web sites are as follows:

Earthquake data:	http://wwwneic.cr.usgs.gov/
Volcano data:	http://volcano.und.nodak.edu/

The "conclusions" section of the laboratory contains many open-ended questions that should be read and analyzed for student understanding of the major concepts.

Write about It

Help students to focus on and integrate what they have learned by asking that they write about and synthesize the information to which they have been exposed. Pick and choose among the essay topics on the student-reproducibles for those that are most relevant to your classroom.

Web-Based Treasure Hunt

There are many exceptional Internet resources available to students. The "Delve Deeper" section of their Extreme 2002 resource guide contains a starting list of some of these. You may wish to have students design and conduct an Internet "treasure hunt" by following their own interests or staying within subject matter parameters you specify.

Ask your students to find and submit a relevant question and its answer (information, fact, or detail) from a Web site of their choice. They should also specify the Web address where they found the information. Compile the students' separate findings into a class treasure hunt that requires students to find each piece of information and so answer each question. You may choose to provide students with a complete list of Internet sites to search (or not). To complete the treasure hunt, ask students to answer each question and specify the Internet address where they located the answer. You may wish to provide an incentive to those students who correctly locate the most information.

This activity is fun, provides students with an opportunity to practice locating specific Web-based information, and exposes them to the vast Internet resources relevant to the deep-sea.

Web Quest

There are two class periods of a Web-based activity entitled **Web Quest,** which have been adapted from materials developed by science teacher Lorraine Caputo (Sussex Central High School, Georgetown, DE). This activity guides students through some of the highlights of the Web site and should be a valuable resource.

Name_____ Date_____

Vocabulary

Here are some words to define. Each is used in your resource guide. Write the definition of each term and its significance to deep-sea research.

Geology Terms

1. bathymetry
2. continental drift
3. fracture zone
4. ocean mapping
5. ocean trench
6. Mid-Ocean Ridge
7. crustal plate
8. seismograph
9. hydrothermal vent
10. continental shelf

Biology Terms

1. chemosynthesis
2. photosynthesis
3. symbiosis
4. extremophile
5. marine snow
6. bioluminescence
7. Archaea
8. tubeworms
9. Pompeii worm
10. enzyme

Deep-Sea Exploration

1. *Alvin*
2. sounding weight
3. fathom
4. sonar
5. Sipper
6. bathysphere
7. bathyscaphe
8. *HMS Challenger*
9. manipulators
10. *Atlantis*

Name_____ Date_____

Deep-Sea Organisms

Either your teacher will assign you the name of a deep-sea organism, or you will select one on your own. For each organism, research the following information. You may have difficulty finding all of the information for every organism. Approach this assignment as an interested detective would.

Common Name_____

Scientific (Latin) Name_____

Kingdom_____

Habitat _____

Body size _____

Diet _____

Interesting adaptations _____

_____

_____

Drawing/ picture (on the back of this sheet, provide a drawing or photograph of the organism). Your teacher may also require you to construct a three-dimensional model of the organism you researched.

Name_____ Date_____

Mathematics Applications I

Technical Support I: Slope and Descent

In October 2002, the submersible *Alvin* will travel to a depth of 2.5 kilometers (1.5 miles) to explore hydrothermal vents. It is critical that the navigators correctly aim the sub so that it arrives at their selected destination. In the following scenarios, imagine that it is your job to help ensure that this happens.

a. If the sub descends at an angle of 25° from the vertical, at what angle will it intersect the ocean floor?
b. If, on a descent to 2.5 kilometers, the sub arrives 1.5 kilometers from its intended destination, what was the actual travel distance?
c. If the *Alvin* were descending in a major ocean current, for every 1.5 miles that it travels downward, the current moves it 4.5 miles horizontally. Use graph paper to plot the actual line of descent, develop an equation that describes this relationship, and determine the slope of descent.

Technical Support II: Descent Rates

In October 2002, the submersible *Alvin* will travel to a depth of 2.5 kilometers (1.5 miles) to explore hydrothermal vents. It is your job to help determine the speed at which the sub travels. Assume the *Alvin* travels 2.5 kilometers to the bottom of the ocean and takes 2 hrs and 10 minutes to reach the bottom.

a. What is the sub's speed in kilometers/ hour?
b. What is its speed in meters/ minute?
c. What is its speed in meters/ second?
d. What is its speed in miles/ hour?

Life Support I: Breathing

To stay healthy, people need to breathe air that is approximately 30% oxygen (O_2). Aboard *Alvin*, an oxygen "drip" replaces O_2 in the air as it is consumed. Your job is to regulate the amount of O_2 in the sub such that the aquanauts can breathe properly.

a. Using the equation $V = 4/3\ \Pi r^3$ to calculate the volume of a sphere, determine how many cubic feet of air are contained within the 6-foot diameter titanium (metal) sphere that houses the people aboard *Alvin*.
b. How many cubic feet of this air is oxygen?
c. If there are three people in the sub and each one uses 3 cubic feet of O_2 per hour, how much O_2 is consumed in a 9-hour round trip to the bottom of the ocean?

Name_____ Date_____

Life Support II: Food and Diet

The *Alvin* needs to be equipped to support human life for 216 man-hours. It is essential that the sub stocks enough food to support its crew for this length of time. It is your job to determine the types and quantities of food to be stocked.

a. If there are three people aboard the sub, how many hours can it stay submerged?
b. How many days can it stay submerged?
c. The information in Liz McCliment's "answers" column tells you the foods needed for a one-day sub trip. Use this information to list the foods and amounts that need to be onboard the sub for three people for the number of days you calculated in "b" above.

Data Analysis: Bacteria

One of the objectives of Extreme 2002 is to determine the amounts and types of bacteria present near deep-sea hydrothermal vents. While the scientists are on the seafloor, they take 1-ml samples of water. In one sample, they determine that there are 60 type "A" bacteria, 45 "B" bacteria, and 3 "C" bacteria.

a. How many of each bacteria type would we expect to find in 1 liter?
b. If there are 2.2 liters in 1 gallon, how many of each bacteria type are in 1 gallon of seawater?

Project Support: Funding

Conducting scientific research of this type is very expensive. Operating the *Atlantis* costs about $30,000 each day plus $8,000 for each dive. Assuming the sub dives 5 times in a week (7 days) calculate the following:

a. How much will a 2-week Extreme 2002 voyage cost??
b. If the National Science Foundation (NSF) provides $400,000 and the National Oceanic and Atmospheric Administration (NOAA) provides $100,000, how much money must the Office of Naval Research (ONR) provide to make up the difference?
c. What fraction of the funding for this research is provided by NSF?

Name_____ Date_____

Mathematics Applications II

Technical Support Group I: Slope and Descent

On January 14, 2000, the submersible *Alvin* traveled to a depth of 2.5 kilometers (1.5 miles) to explore a hydrothermal vent. It was critical that the navigators correctly aimed the sub so that it arrived at their selected destination. In the following scenarios, imagine that it is your job to help ensure that this happens.

a. If the sub descends at an angle of 15° from the vertical, at what angle will it intersect the ocean floor?
b. If the sub arrives 1.5 kilometers from its intended destination, what was the actual travel distance?
c. If the *Alvin* is descending in a minor ocean current, for every 1.0 mile that it travels downward, the current moves it 0.5 miles horizontally. Use graph paper to plot the actual line of descent, develop an equation that describes this line, and determine the slope of descent.

Technical Support Group II: Descent Rates

On January 14, 2000, the submersible *Alvin* traveled to a depth of 2.0 kilometers (0.9 miles) to explore a hydrothermal vent. It is your job to help determine the speed at which the sub traveled. Assume the *Alvin* traveled 2.0 kilometers to the bottom of the ocean and took 2 hrs and 15 minutes to reach the bottom.

a. What was the sub's speed in kilometers/ hour?
b. What was its speed in meters/minute?
c. What was its speed in meters/second?
d. What was its speed in miles/hour?

Life Support I: Breathing

To stay healthy, people need to breathe air that is 30% oxygen (O_2). Aboard the French sub *Nautil*, an oxygen "drip" replaces O_2 in the air as it is consumed. Your job is to regulate the amount of O_2 in the sub such that the aquanauts can breathe properly.

a. Using the equation $V = 4/3\ \Pi r^3$ to calculate the volume of a sphere, determine how many cubic meters of air are contained within the 2-meter diameter titanium (metal) sphere that houses the people aboard the *Nautil*.
b. How many cubic meters of this air is oxygen?
c. If there are three people in the sub and each one uses 0.5 cubic meters of O_2 per hour, how much O_2 is consumed in a 9-hour round trip to the bottom of the ocean?

Name_____ Date_____

Life Support II: Food and Diet

The *Alvin* needs to be equipped to support human life for 216 man-hours. It is essential that the sub stocks enough food to support its crew for this length of time. It is your job to determine the types and quantities of food to be stocked.

a. If there are two people aboard the sub, how many hours can it stay submerged?

b. How many days can it stay submerged?

c. The information in Liz McCliment's "answers" column tells you the foods needed for a one-day sub trip. Use this information to list the foods and amounts that need to be onboard the sub for two people for the number of days you calculated in "b" above.

Data Analysis: Vent Worms

Imagine that one of the objectives of Extreme 2002 is to determine the density and growth rates of giant tubeworms and clams living near deep-sea hydrothermal vents. While the scientists are below, they take 1-meter population samples. In one square meter of ocean bottom, they determine that there are 23 giant worms and 18 giant clams. The area around this vent chimney is 300 square meters.

a. How many of each organism type would we expect to find around this vent chimney?

b. If there are 10.2 square feet in a square meter, how many of each animal type are in 1 square foot of ocean bottom?

Project Support: Funding

Conducting scientific research of this type is very expensive. Operating the *Atlantis* costs about $30,000 each day plus $8,000 for each dive. If the sub were to dive 6 times in a week (7 days) calculate the following:

a. How much would a 3-week voyage cost??

b. If the National Science Foundation (NSF) provided $600,000 and the National Oceanic and Atmospheric Administration (NOAA) provided $100,000, how much money must the Office of Naval Research (ONR) provide to make up the difference?

c. According to the preceding figures, what fraction of the funding for this cruise would have been provided by NSF?

Name_____ Date_____

Crustal Plates Laboratory

Introduction:

The purpose of the following activity is to help you determine relationships among earthquakes, volcanoes, and plate boundaries. You will need a map of the Earth that includes crustal plate boundaries, and whether each is convergent or divergent.

Plot the latitude and longitude of the earthquakes and volcanoes that your teacher assigns you. Mark the earthquake sites with a blue pen and the volcano sites with a red pen. When you have finished plotting the location of each geologic event, analyze your data by answering the questions below.

Data:

There are many sources of interesting data that will work for this lab. Your teacher will give you the data you are to plot.

Conclusions:

Respond to the following questions on a separate sheet of paper.

1. What do you notice about the relationships among the locations of earthquakes, volcanoes, and plate boundaries?
2. Which type of plate boundary typically results in oceanic trenches?
3. Which type of plate boundary typically results in hydrothermal vents?
4. Which type of plate boundary typically results in mountains?
5. Which type of plate boundary typically forms volcanoes?
6. At which type(s) of plate boundaries do the most earthquakes seem to occur?
7. Which country or area has had the most **volcanic eruptions** during the time period you analyzed?
8. Which country or area has had the most **earthquakes** during the time period you analyzed?
9. Is the region in which you live likely to experience volcanoes or earthquakes? Explain.
10. Write a question you have about the relationships among volcanoes, earthquakes, and plate boundaries. Do you have enough information to answer your question? If not, what additional data would you need?

Name_____ Date_____

Complete Global Listing of Earthquakes Occurring During the First Five Days of July 2001

year mm dd	Latitude	Longitude	Location
2001 07 05	15.915S	73.524W	SOUTHERN PERU.
2001 07 05	32.366N	139.512E	SOUTHEAST OF HONSHU, JAPAN
2001 07 05	32.358N	139.612E	SOUTHEAST OF HONSHU, JAPAN
2001 07 04	32.627N	139.438E	SOUTHEAST OF HONSHU, JAPAN.
2001 07 04	32.282N	139.523E	SOUTHEAST OF HONSHU, JAPAN
2001 07 04	36.700N	121.340W	CENTRAL CALIFORNIA.
2001 07 04	16.814S	65.185W	CENTRAL BOLIVIA.
2001 07 04	21.604S	176.711W	FIJI ISLANDS REGION.
2001 07 04	36.690N	121.320W	CENTRAL CALIFORNIA.
2001 07 04	39.990S	175.080E	NORTH ISLAND, NEW ZEALAND.
2001 07 03	36.686N	121.311W	CENTRAL CALIFORNIA.
2001 07 03	36.700N	121.330W	CENTRAL CALIFORNIA.
2001 07 03	36.700N	121.330W	CENTRAL CALIFORNIA.
2001 07 03	36.683N	121.319W	CENTRAL CALIFORNIA.
2001 07 03	36.696N	121.329W	CENTRAL CALIFORNIA.
2001 07 03	38.000S	176.280E	NORTH ISLAND, NEW ZEALAND.
2001 07 03	32.267N	139.442E	SOUTHEAST OF HONSHU, JAPAN
2001 07 03	21.608N	143.009E	MARIANA ISLANDS REGION.
2001 07 03	16.510S	73.747W	NEAR COAST OF PERU.
2001 07 03	34.260N	116.760W	SOUTHERN CALIFORNIA.
2001 07 03	6.041S	154.749E	SOLOMON ISLANDS.
2001 07 03	16.951N	60.399W	LEEWARD ISLANDS
2001 07 02	5.150S	102.739E	SOUTHERN SUMATERA, INDONESIA
2001 07 02	38.299N	73.142E	TAJIKISTAN-XINJIANG BORDER REG.
2001 07 02	36.700N	121.330W	CENTRAL CALIFORNIA.
2001 07 02	7.143S	129.240E	BANDA SEA
2001 07 02	59.646N	151.673W	KENAI PENINSULA, ALASKA.
2001 07 02	36.690N	121.330W	CENTRAL CALIFORNIA.
2001 07 02	36.700N	121.330W	CENTRAL CALIFORNIA.
2001 07 02	33.250N	117.480W	SOUTHERN CALIFORNIA.
2001 07 02	30.647N	86.472E	XIZANG
2001 07 02	36.700N	121.330W	CENTRAL CALIFORNIA.
2001 07 02	27.862S	176.596W	KERMADEC ISLANDS REGION
2001 07 02	16.901S	173.172W	TONGA ISLANDS
2001 07 02	253.270N	170.417E	NEAR ISLANDS, ALEUTIAN ISLANDS
2001 07 02	44.524N	148.068E	KURIL ISLANDS
2001 07 02	1.634N	122.948E	MINAHASSA PENINSULA, SULAWESI

year mm dd	Latitude	Longitude	Location
2001 07 02	52.752N	174.699E	NEAR ISLANDS, ALEUTIAN ISLANDS
2001 07 02	4.251S	152.960E	NEW BRITAIN REGION, P.N.G.
2001 07 02	28.630N	129.685E	RYUKYU ISLANDS, JAPAN.
2001 07 02	0.455N	125.155E	NORTHERN MOLUCCA SEA
2001 07 01	17.947S	71.576W	NEAR COAST OF PERU.
2001 07 01	6.756N	73.048W	NORTHERN COLOMBIA
2001 07 01	23.083N	121.419E	TAIWAN.

Source: National Earthquake Information Center
World Data Center for Seismology, Denver
URL: http://neic.usgs.gov/neis/qed/qed.html

Name_____ Date_____

Update on Current Volcanic Activity, 2001

VOLCANO	LOCATION	DATE	LATITUDE	LONGITUDE
Etna	Sicily, Italy	July 6	200137.7N,	15.0E
Tungurahua	Ecuador	July 6	1.467S	78.44W
Sheveluch	Russia	July 2	56.65N	161.36E
Mayon	Philippines	June 25	13.3N	123.7E
Lopevi	Vanuatu	June 15	16.507S	168.346E
Colima	Mexico	June 5	19.51N	103.62W
Popocatepetl	Mexico	June 5	19.0N	98.6W
Mount Oyama	Japan	May 24	34.08N	139.53E
Lokon	Sulawesi, Indonesia	May 24	1.36N	124.79E
San Cristobal	Nicaragua	May 16	12.7N	87.0W
South Sister	Oregon	May 11	44.1N	121.75W
Ulawun	Papua New Guinea	May 2	5.1S	151.3E
Masaya	Nicaragua	April 24	12.0N	86.2N
Krakatau	Indonesia	April 12	6.10S	105.42E
Maroa	New Zealand	April 11	38.4S	176.1E
Jackson	Gorda Ridge	April 9	42.66N	126.78W
Canlaon	Philippines	April 5	10.4N	123.1E
Piton de la Fournaise	Island of Reunion	April 4	21.23S	55.71E
Arenal	Costa Rica	March 24	10.46N	84.70W
Merapi	Java, Indonesia	March 21	.54S	110.44E
Cleveland	Alaska	March 19	52.49N	169.57W
Kliuchevskoi	Kamchatka, Russia	March 9	56.06N	160.64E
Pacaya	Guatemala	March 2	14.4N	90.6W
Ijen	Java, Indonesia	February 15	8.1S	114.2E
Karangetang	Siau Island, Indonesia	February 9	2.78N	125.48E
Nyamuragira	Congo, Africa	February 7	1.4S	29.2E
Kelut	Java, Indonesia	February 2	7.9S	112.3E
Rotorua	New Zealand	February 1	38.1S	176.3E

Name_____ Date_____

Write about It

Your teacher may assign one or more of the following essay topics for your exploration.

1. Why is it important to conduct research in the deep sea? How does such research benefit individuals, society, and the environment?

2. Science, technology, and society are inextricably linked because societal values impinge upon what scientific questions are deemed important, while technological innovations both affect societal priorities and enable new types of research. Describe the ways in which technology, society, and deep-sea research are interrelated.

3. Compare and contrast photosynthesis and chemosynthesis.

4. Cutting-edge scientific research often involves many different researchers with varying specialties. Describe how collaborations among people with different specialties may be essential for deepening our understanding of the deep sea.

5. If you were able to design and conduct research in hydrothermal vent ecosystems, what questions would you be most compelled to ask and attempt to answer? Why do you think these questions are important?

6. Some individuals have suggested that because the deep sea is so vast and generally inaccessible, it would make a good dumping ground for toxic, nuclear, and other waste materials. Do you think this is a good plan? Why or why not?

7. Hydrothermal vents are dynamic places that are constantly changing and evolving. New vents form while old vents die out as the geologic forces that created them move on. Given the relatively sedentary nature of most vent organisms, propose a mechanism by which they might colonize a newly formed vent.

8. Imagine that you are a scientist aboard *Alvin*. Describe what you see out of your porthole window as you travel 1.5 miles downward over the course of two hours. How does what you view change? Describe any organisms you encounter.

Name: Date:

Welcome Aboard the Extreme 2002: Mission to the Abyss
Introductory Web Quest!
www.ocean.udel.edu/extreme2002

1. Once you are on-line, type in the Extreme 2002 address in the URL (go to) box. The address is shown above.

2. DIVE IN screen. After the porthole opens, click on the logo to ENTER.

3. Click on MISSION & CREW.

4. Click on WELCOME ABOARD. Read over the introductory statement and then click on the speaker to listen to Dr. Cary. When complete, close the box (by clicking on the x at the top right of the box).

5. Click on DIVE LOCATION. Review the page, clicking on stars located on the map to get a perspective on where scientists are located and doing their research.

6. Summarize the FAST FACT that is located on this page.

_____

_____

_____

7. How deep is the ocean? Click on the appropriate box to find the answer.

_____

8. Click back to the MISSION & CREW page.

9. Click on SUBMERSIBLE ALVIN. Review this page. Write an interesting question and answer that appear on this page.

_____

_____

_____

10. Click on R/V ATLANTIS. Answer the following questions:

What is UNOLS all about?

_____

_____

What does R/V stand for?

_____

_____

How did the *Atlantis* get her name?

_____

_____

Where is the *Atlantis* now?

_____

_____

10. Go to the top of the page and click on HOME. You should now be back at the Extreme 2002 home page. Click on MISSION & CREW. Read over the page and use your mouse pointer to highlight several names and see the pictures of those individuals. This should give you an idea of who is on the ship.

11. Go back to the HOME PAGE and click on the WRITE THE SCIENTISTS button. Review this page. Begin thinking about a question you might want to pose to the researchers or crew. You will need to select one good question by the end of our session. When you have a good question, write it down here. Type it in after receiving approval from your teacher.

_____

_____

_____

12. Now type this address in the URL (go to) box to learn about other expeditions that have been conducted in the University of Delaware's EXTREME series: http://www.ocean.udel.edu/expeditions.

13. Click on the EXTREME 2001 link. Once you enter the site, click on the DAILY DISCOVERIES box.

14. Click on NEAT STUFF. Click on EXTREME 2001 SCHOOL TEAM. Look to see if any classes from your school and/or state participated in EXTREME 2001.

15. Use your back arrow to return to the NEAT STUFF page. Click on October 19th. What was significant about this day? Scroll down to look at the pictures and search for an answer to this question.

_____

_____

16. Use your back arrow to return to the NEAT STUFF page. Click on another few dates and review the pictures. These should give you some ideas about how this year's mission might go. Scroll down to view the pictures. When you are finished looking at the pictures, click on your back arrow to return to the DAILY DISCOVERIES page.

17. When you reach the DAILY DISCOVERIES page, click on DIVE LOG and choose a date to read a log entry. Return to the DAILY DISCOVERIES page by using your back arrow.

18. Click on DAILY JOURNAL, choose a date, and review it. When you have finished reading it, click on HOME at the top left corner. You should now be in the EXTREME 2001: A DEEP-SEA ODYSSEY page. Use the back key to get to the On-Line Expeditions page. Click on the EXTREME 2002 box. Click on ENTER.

19. At the EXTREME 2002 HOME PAGE, click on CREATURE FEATURES, SEAFLOOR GEOLOGY, or HIGH-TECH TOOLS. Fill in the details below about your finds.

NAME and DESCRIPTION of your COOL FINDS:

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

21. Click on the HOME arrow. Go to WRITE THE SCIENTISTS. By now, you should now have formulated a good question to type in. When you are finished, use the back key to go to the HOME PAGE.

Name: Date:

Welcome Aboard the Extreme 2002: Mission to the Abyss
Web Quest 2!
www.ocean.udel.edu/extreme2002

1. Once you are on-line, type in the Extreme 2002 address in the URL (go to) box. The address is shown above.

2. DIVE IN screen. After the porthole opens, click on the logo to ENTER.

3. Click on WRITE THE SCIENTISTS. Scroll down and find an interesting question. Read the question and answer and explain in your own words what you have learned.

_____

_____

_____

4. Scroll through the questions and find another interesting question, read the response and summarize what you found:

_____

_____

_____

DID YOU FIND YOUR QUESTION?

5. Use the back key and on the home page, click on DAILY DISCOVERIES. Click on a date. Explain something important that happened on that date.

_____

_____

6. On the DAILY DISCOVERIES page, click on NEAT STUFF. Click on several dive dates. Scroll down and look at the pictures. Find and tell about something particularly interesting that happened on one of the dive dates.

_____

_____

_____

7. Click on the back key, and then click on CREATURE FEATURES. Then click on LIFE IN THE ABYSS. Read over the paragraphs. What is the greatest depth at which a fish has been recorded?

_____

8. Scroll down and look at the various creatures. Click on different deep-sea inhabitants to find the answer to this question: Why do deep-sea fish rely on *bioluminescent* (light-producing) organs?

_____

_____

_____

9. Which creature is called the "flower of the sea"?

_____

_____

10. Use the back key to get to the main menu. Click on HIGH-TECH TOOLS. Read it over and choose one tool. Summarize the purpose for which the tool is used.

_____

_____

_____

11. If you are taking part in the Phone Call to the Deep, have you thought of a question to ask the scientists?

Sponsored by the University of Delaware College of Marine Studies with support from the National Science Foundation

Project Evaluation — A Note to Teachers

by John Gause, The Jefferson School, Georgetown, Delaware

The "Extreme 2002" team is a diverse group of professionals from a great variety of disciplines. From the grants managers to the curriculum developers, from the technicians and sailors to the Web masters, from the public relations professionals to the telecommunications operators, and from the scientists to the educators, people from all over the country play a vital role in this project. We are delighted that by signing your school up for this opportunity, you have become a part of our team.

The following pages contain the PROJECT EVALUATION. It includes a 20-question, content-focused section with multiple choice, true/false, and vocabulary definition items. This section is followed by the student survey. Finally, there is an inferential question that asks the student to use information presented and apply principles of scientific method. The content and survey sections of the student assessment appear in pre-test and post-test versions. An answer key for the content section also is provided. Finally, there is a teacher survey and evaluation summary.

The PROJECT EVALUATION is designed to help see how the students are doing and how we, the "Extreme Team," are doing. Information on student achievement and input from participating teachers are essential factors as the team works to expand and improve this unique, educational endeavor. Your response will be used in everything from curriculum design and materials development to grant writing and funding solicitation.

Toward these noble ends, we recommend that the pre-test version (content and survey) be given to the students as early in your planning as possible and that the post-test be a culminating activity. Then, and here comes the hard part, we ask that the numbers get crunched and added to the results summary along with your response to a brief survey. We will have an on-line version of this available in the near future so that you can submit your results to us electronically. If you would rather mail us your teacher survey/evaluation summary, please send the completed forms to the address below:

University of Delaware
Marine Public Education Office
222 S. Chapel Street
Newark, DE 19716-3530
ATTN: Extreme 2002

Thanks for your hard work and dedication in bringing science to life and bringing the deep sea into your classroom. It's great working with you!

Outline of Evaluation Packet

1.) Pre-test — Content
2.) Pre-test — Survey
3.) Post-test — Content
4.) Post-test — Survey
5.) Inference & Method* — YOU BE THE SCIENTIST
6.) Answer Key
7.) Teacher Survey & Results Summary

EXTREME 2002: MISSION TO THE ABYSS

Evaluation Pre-test NAME:_____

1.) How deep is most of the ocean?
a.) about one-half mile
b.) 3 kilometers
c.) 7 kilometers
d.) 25 miles

2.) What percentage of the Earth's surface is covered with water?
a.) 50%
b.) 62%
c.) 70%
d.) 37%

What is one way in which fish in the deep sea are specifically adapted for life in that region?
a.) peripheral nervous system
b.) isotherms
c.) epithelial tissue
d.) bioluminescence

4.) Which of these do scientists on the EXTREME 2002 dive consider to be the primary goal of deep-sea exploration?
a.) to uncover the mysteries of early civilizations
b.) to prove the value of advances in undersea technology
c.) to understand how organisms survive the extreme conditions
d.) to quantify sources of groundwater contaminants
e.) to propose alternative food sources for an ever-increasing human population

5.) What is a hydrothermal vent?
a.) an underwater geyser created by super-heated water from a fissure in the Earth's crust
b.) a tool used to heat homes using warmed water run through pipes
c.) a hole drilled in the side of a volcano to release pressure
d.) a tool used by scientists to measure temperature and pressure in the deep sea

6.) What is the function of endosymbiotic bacteria?
a.) to help attract prey
b.) to provide their host with food
c.) to help sense heat
d.) to provide flotation

7.) What physical features of hydrothermal vents make them particularly extreme environments?
a.) they are very cold
b.) high temperatures and toxic chemicals
c.) huge pressure
d.) high altitude

8.) Why do the plates, which make up the Earth's crust, constantly shift?
a.) the rotation of the Earth
b.) molten rock, beneath the plates, propels them
c.) pressure from tidal fluctuations in surface water
d.) erosion

9.) The first submarine is thought to have been powered by:
a.) internal combustion engine
b.) oars
c.) nuclear power
d.) pedals

10.) A realistic description of the vent microbe *Arcobacter sulfidicus* might be:
a.) It eats poison and secretes building material
b.) It eats worms and secretes poison
c.) It eats "marine snow" and secretes energy
d.) It eats building material and secretes poison
e.) It eats lightning and secretes thunder

TRUE OR FALSE Do the Follow-Up, Too — Explain Your Answer!

1.) TRUE / FALSE: The amazing advances in underwater and computer technologies have allowed scientists to accurately predict what they will find on their deep-sea dives, and how their findings may be applied to benefit humankind.

Follow-up: _____

_____

2.) TRUE / FALSE: All organisms on the planet derive their energy from the sun through a process known as photosynthesis.

Follow-up: _____

_____

3.) TRUE / FALSE: The investigation of extreme environments has a possible connection to the existence of life on other planets.

Follow-up: _____

_____

4.) TRUE / FALSE: The plates which make up the Earth's crust can move up to 10 meters (32.5 feet) in one year.

Follow-up: _____

_____

5.) TRUE / FALSE: Deep-sea dives to conduct scientific exploration and investigation are interdisciplinary endeavors, which include biology, chemistry, geology, technology, history, economics, and government.

Follow-up: _____

_____

DEFINITIONS

1.) bathymetry: _____

_____

_____

2.) symbiosis: _____

_____

_____

3.) continental shelf: _____

_____

_____

4.) fathom: _____

_____

_____

5.) Pompeii worm: _____

_____

_____

EXTREME 2002: MISSION TO THE ABYSS

Pre-test Survey NAME:_____

Please respond by circling a number that reflects your opinion on the following statements:

"Importance"

1.) What goes on in the deep ocean directly affects my life.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

2.) Stewardship, the thoughtful protection and maintenance, of the deep ocean environment is an important personal value.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

3.) Research in the deep ocean is an important national concern.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

"Interest"

4.) I appreciate the deep ocean.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

5.) The study of hydrothermal vent sites is interesting.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

6.) The study of extreme environments is something I may want to pursue in the future.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

EXTREME 2002: MISSION TO THE ABYSS

Evaluation Post-test NAME:_____

1.) How deep is most of the ocean?
a.) about one-half mile
b.) 3 kilometers
c.) 7 kilometers
d.) 25 miles

2.) What percentage of the Earth's surface is covered with water?
a.) 50%
b.) 62%
c.) 70%
d.) 37%

What is one way in which fish in the deep sea are specifically adapted for life in that region?
a.) peripheral nervous system
b.) isotherms
c.) epithelial tissue
d.) bioluminescence

4.) Which of these do scientists on the EXTREME 2001 dive consider to be the primary goal of deep-sea exploration?
a.) to uncover the mysteries of early civilizations
b.) to prove the value of advances in undersea technology
c.) to understand how organisms survive the extreme conditions
d.) to quantify sources of groundwater contaminants
e.) to propose alternative food sources for an ever-increasing human population

5.) What is a hydrothermal vent?
a.) an underwater geyser created by super-heated water from a fissure in the Earth's crust
b.) a tool used to heat homes using warmed water run through pipes
c.) a hole drilled in the side of a volcano to release pressure
d.) a tool used by scientists to measure temperature and pressure in the deep sea

6.) What is the function of endosymbiotic bacteria?
a.) to help attract prey
b.) to provide their host with food
c.) to help sense heat
d.) to provide flotation

7.) What physical features of hydrothermal vents make them particularly extreme environments?
a.) they are very cold
b.) high temperatures and toxic chemicals
c.) huge pressure
d.) high altitude

8.) Why do the plates, which make up the Earth's crust, constantly shift?
a.) the rotation of the Earth
b.) molten rock, beneath the plates, propels them
c.) pressure from tidal fluctuations in surface water
d.) erosion

9.) The first submarine is thought to have been powered by:
a.) internal combustion engine
b.) oars
c.) nuclear power
d.) pedals

10.) A realistic description of the vent microbe *Arcobacter sulfidicus* might be:
a.) It eats poison and secretes building material
b.) It eats worms and secretes poison
c.) It eats "marine snow" and secretes energy
d.) It eats building material and secretes poison
e.) It eats lightning and secretes thunder

TRUE OR FALSE Do the Follow-Up, Too — Explain Your Answer!

1.) TRUE / FALSE: The amazing advances in underwater and computer technologies have allowed scientists to accurately predict what they will find on their deep-sea dives, and how their findings may be applied to benefit humankind.

Follow-up: _____

_____

2.) TRUE / FALSE: All organisms on the planet derive their energy from the sun through a process known as photosynthesis.

Follow-up: _____

_____

3.) TRUE / FALSE: The investigation of extreme environments has a possible connection to the existence of life on other planets.

Follow-up: _____

_____

4.) TRUE / FALSE: The plates which make up the Earth's crust can move up to 10 meters (32.5 feet) in one year.

Follow-up: _____

_____

5.) TRUE / FALSE: Deep-sea dives to conduct scientific exploration and investigation are interdisciplinary endeavors, which include biology, chemistry, geology, technology, history, economics, and government.

Follow-up: _____

_____

DEFINITIONS

1.) bathymetry: _____

_____

_____

2.) symbiosis: _____

_____

_____

3.) continental shelf: _____

_____

_____

4.) fathom: _____

_____

_____

5.) Pompeii worm: _____

_____

_____

EXTREME 2002: MISSION TO THE ABYSS

Post-test Survey NAME:_____

Please respond by circling a number that reflects your opinion on the following statements:

"Importance"

1.) What goes on in the deep ocean directly affects my life.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

2.) Stewardship, the thoughtful protection and maintenance, of the deep ocean environment is an important personal value.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

3.) Research in the deep ocean is an important national concern.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

"Interest"

4.) I appreciate the deep ocean.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

5.) The study of hydrothermal vent sites is interesting.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

6.) The study of extreme environments is something I may want to pursue in the future.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

INFERENCE & METHOD:
You Be the Scientist!

Is there a pressing question — a societal need — or even just a cool idea, the answer to which can be found on the ocean floor? In other extreme environments? Something the "Extreme Team" has missed??

Here is an example of something Dr. Cary is looking into. Check it out, and then let your imagination go. Yeah, you be the scientist. Write your question or topic, how you imagine it may turn out (hypothesis), and some plan for getting to the "bottom" of it.

Your teacher may submit your idea to the "Extreme Team," and it may become part of the investigation on the next dive to the ocean floor! Your turn!

	Dr. Cary
Question:	How do bacteria at the vent site affect minerals in the vent chimney?
Hypothesis:	Initial colonization affects the structure and composition of minerals being deposited at the vent site. Pioneer bacteria will be never-before-seen organisms and be very thermophilic.
Procedure:	1.) Design and construct instrument to collect new chimney intact from ocean floor with minimal contamination from surrounding seawater.
	2.) Measure temperature and chemistry of water surrounding new chimney.
	3.) Collect chimney sample from seafloor.
	4.) Sample on ship *aseptically,* test for contamination, store frozen.
	5.) Examine samples using genetic tools for number and type of bacteria, noting particularly where sample comes from on the chimney.
	6.) Determine mineral composition using electron microscopy, microprobes, and x-ray analysis.
	7.) Coordinate mineral analysis with bacterial analysis. With multiple sampling of the same chimney at different times, we should get a clear timetable of bacterial colonization and its effects on the minerals in the chimney.

	Name:_____
Question:	
Hypothesis:	
Procedure:	1.)
	2.)
	3.)
	4.)
	5.)
	6.)
	7.)

EXTREME 2002: MISSION TO THE ABYSS

Evaluation Answer Key

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d.) It eats building material and secretes poison
e.) It eats lightning and secretes thunder

TRUE OR FALSE- Use follow-up space to briefly explain.

1.) TRUE / FALSE: The amazing advances in underwater and computer technologies have allowed scientists to accurately predict what they will find on their deep-sea dives, and how their findings may be applied to benefit humankind.

Follow-up: The scientific process is fallible, fluid, and sometimes unpredictable.

2.) TRUE / FALSE: All organisms on the planet derive their energy from the sun through a process known as photosynthesis.

Follow-up: No sun reaches the deep ocean. Chemosynthesis drives that world.

3.) TRUE / FALSE: The investigation of extreme environments has a possible connection to the existence of life on other planets.

Follow-up: Extreme temperatures and toxic chemicals exist in many places in the universe. If life can exist in the deep ocean . . .

4.) TRUE / FALSE: The plates which make up the Earth's crust can move up to 10 meters (32.5 feet) in one year.

Follow-up: Whoa! What a seismic mess we would have then!

5.) TRUE / FALSE: Deep-sea dives to conduct scientific exploration and investigation are interdisciplinary endeavors which include biology, chemistry, geology, technology, history, economics, and government.

Follow-up: All of these, and we bet you could think of more!

DEFINITIONS

1.) *bathymetry:* Measurement of the depth of a large body of water.

2.) *symbiosis:* The close association of animals or plants of different species to their mutual benefit.

3.) *continental shelf:* The area of the seafloor adjacent to the land, extending to a depth of 200 meters.

4.) *fathom:* Unit of length/depth equal to 6 feet. (1.83 meters)

5.) *Pompeii worm:* A small (max. size = 13 cm) polychaete worm that builds dense colonies on the sides of deep-sea hydrothermal vent chimneys in the Eastern Pacific Ocean. It is thought to be the most heat-tolerant animal on the planet.

EXTREME 2002: MISSION TO THE ABYSS

Teacher Survey & Evaluation Summary

Teacher Survey

Please evaluate the usefulness and applicability of these aspects of the Extreme 2002 curriculum.

RESOURCE GUIDE

1	2	3	4	5	6	7	8	9	10
not				somewhat				very	

VIDEO

1	2	3	4	5	6	7	8	9	10
not				somewhat				very	

CURRICULUM GUIDE & FRAMEWORK

1	2	3	4	5	6	7	8	9	10
not				somewhat				very	

SUPPLEMENTARY ACTIVITIES

1	2	3	4	5	6	7	8	9	10
not				somewhat				very	

WEB PAGE

1	2	3	4	5	6	7	8	9	10
not				somewhat				very	

PHONE CALL/WRITE THE SCIENTISTS

1	2	3	4	5	6	7	8	9	10
not				somewhat				very	

EXTREME EXPERIMENT

1	2	3	4	5	6	7	8	9	10
not				somewhat				very	

STUDENT EVALUATION, SURVEY & SUMMARY

1	2	3	4	5	6	7	8	9	10
not				somewhat				very	

Comments:_____

_____

_____

_____

_____

Please respond by circling a number that reflects your opinion on the following statements:

The "Extreme 2002" curriculum aligns well with district/state/national science education standards.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

"Extreme 2002" enhanced my students' knowledge of our school's science curriculum content.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

"Extreme 2002" enhanced my students' understanding of the scientific process and method.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

I would recommend this program to science teachers in other schools.

1	2	3	4	5	6	7	8	9	10
strongly disagree			disagree			agree			strongly agree

Comments:_____

Evaluation Summary

1.) Average # correct/20 — Pre-test: _____

Average # correct/20 — Post-test: _____

2.) "Importance Quotient"

(Total of survey points from items 1, 2 & 3 on student survey)
÷ number of students

Pre-test: _____

Post-test: _____

* Survey point is the number circled by students for each item.

3.) "Interest Quotient"

(Total of survey points from items 4, 5 & 6 on student survey)
÷ number of students

Pre-test: _____

Post-test: _____

4.) Quotable Quote

Please jot down the most noteworthy student observation or comment from the "quote" section of the student survey post-test.

_____

_____

_____

(optional) Student Name: _____

Grade: _____ School: _____

5.) You Be the Scientist

Please write what you consider to be the most valid question or topic generated by your students in the "Inference/Method" section.

_____

_____

_____

_____

(optional) Student Name: _____

Grade: _____ School: _____